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MK 12 SSDS AIR MODE TECHNICAL EVALUATION T/S 283.(U)
JUL 76 B A RIDGEWELL
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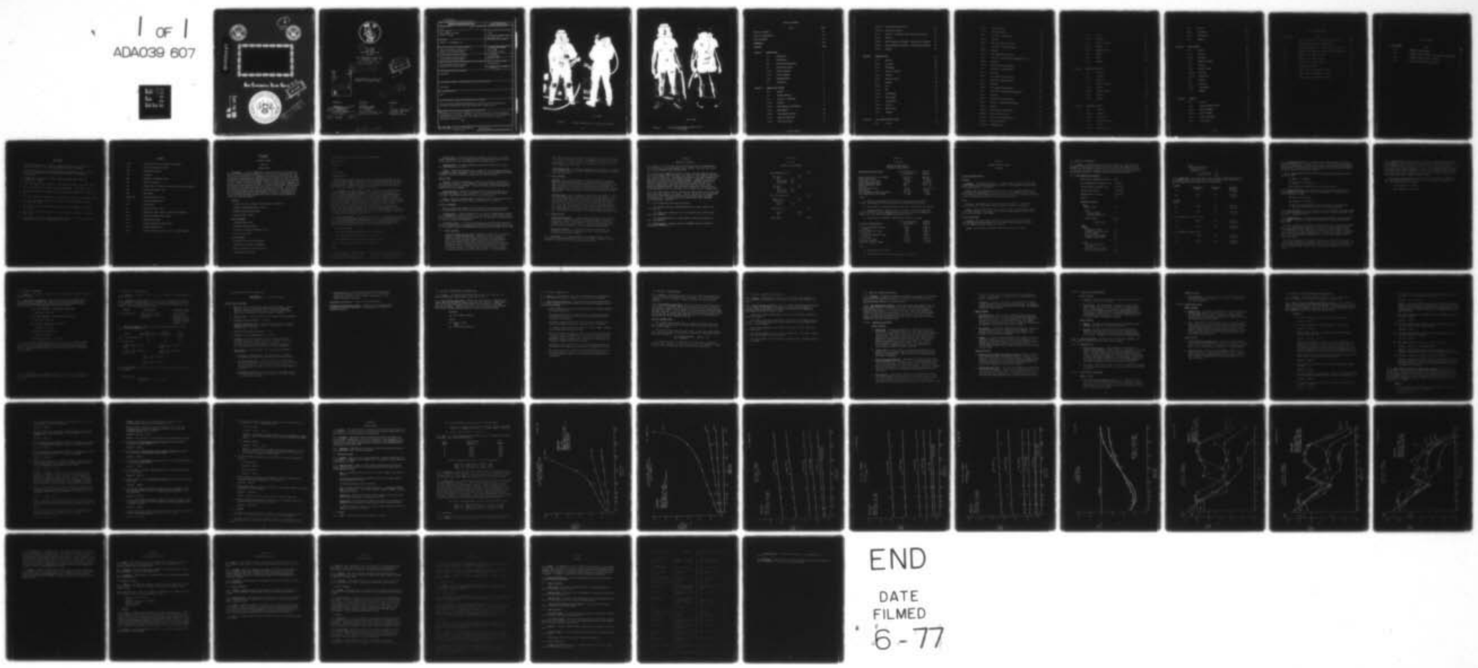

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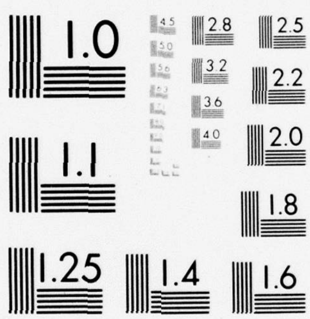

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NAVY EXPERIMENTAL DIVING UNIT

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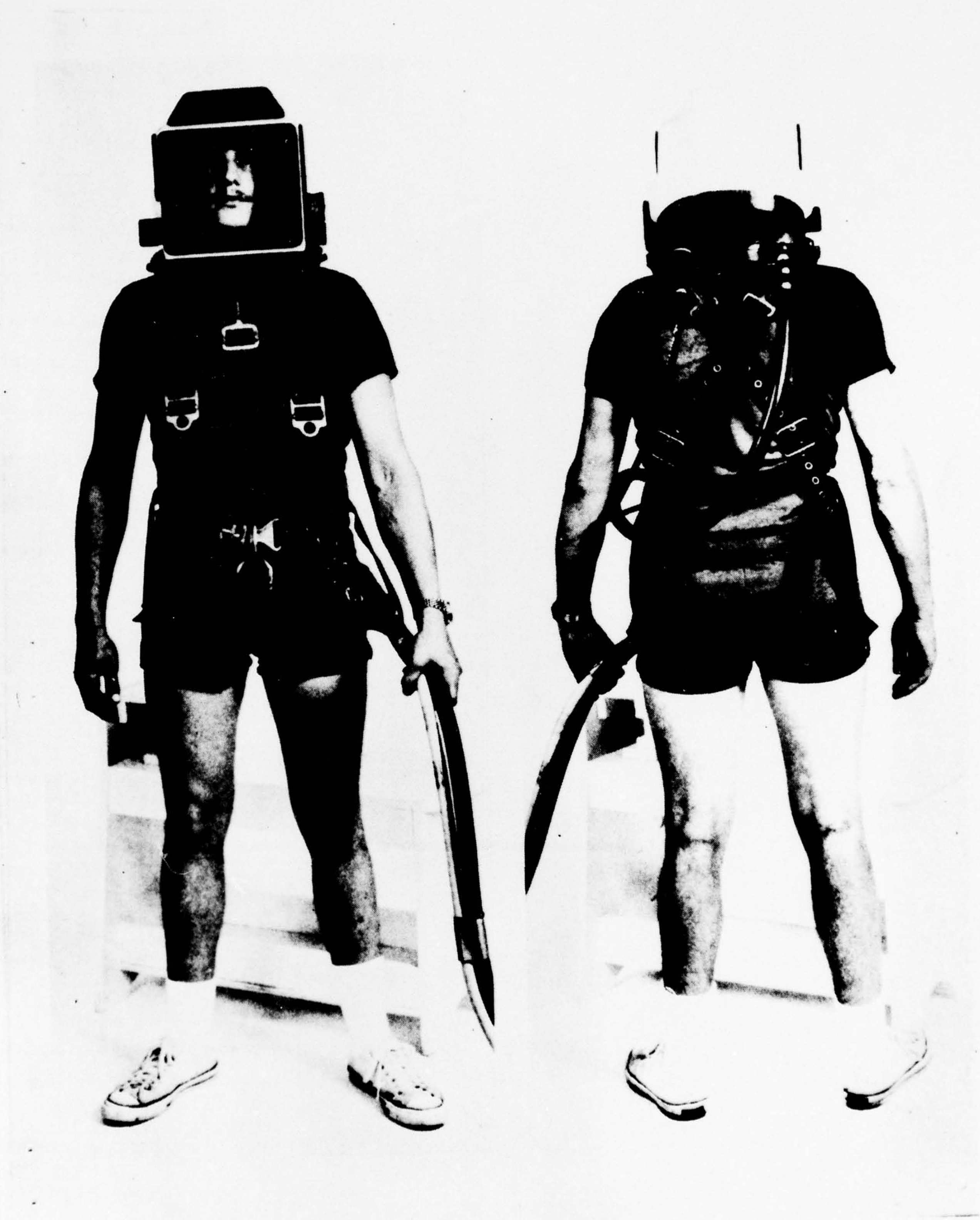
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Summary of the Technical Evaluation Testing of the MK 12 Surface Supported Diving System, air mode. Compares required characteristics and operational parameters with test results. Concludes that the system is ready for Operational Evaluation.

MK 12 SSDS

FIGURE 1 Bottom Configuration, Air Mode with Dry Suit



MK 12 SSDS

FIGURE 2 Swimming Configuration, Wet/Swim Suit

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

REFERENCES

1. Technical Evaluation of the Surface Supported Diving System, USN MARK XII, Interium Report No. 7-74. Navy Experimental Diving Unit (NEDU).

2. NEDU Research Report 16-74, Determination of the Adequacy of Helmet Ventilation in a Prototype Navy MK-12 and the MK-5 Hard Hat Diving Apparatus. 16 July 1974.

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GLOSSARY

ACFM	- Actual cubic feet per minute of gas flow.
ADM	- Advanced Development Model.
BPM	- Breaths per minute.
db	- Decibels.
dbA	- Decibels, A weighted scale.
FSW	- Feet of sea water.
Hz	- Hertz; unit of electrical frequency (cycles per second).
LPM	- Liters per minute, flow.
MIC	- Microphone.
Mixed Gas	- Any gas other than air.
ΔP	- Pressure differential.
O.B.	- Over bottom.
psi	- Pounds per square inch.
psid	- Pounds per square inch of differential pressure.
psig	- Pounds per square inch, gauge.
S.E.	- Surface equivalent.
SSDS	- Surface Supported Diving System.
Sur-D	- Surface decompression.
Whip	- A short connecting piece of hose or cable (leader).

MK 12 SSDS
AIR MODE

TECHEVAL REPORT

Section 1

INTRODUCTION

1.1 Background. The MK 12 SSDS was developed to provide the Navy with two distinctly different diving capabilities, using the same diving system. The first, and most important, is a shallow water salvage capability for use when a lightweight diving system is unsuitable; and the second is a deep dive capability for use when saturation diving equipment is impractical or not available. The MK 12 system replaces the older MK V "hard hat" system, which had been the standard in the U. S. Navy since 1918. The Navy Salvage Divers capability has been severely restrained due to lack of research and development in diving and the failure to use modern materials and production techniques. In a survey conducted by the Navy in 1971, it was determined that a single diving system meeting Navy requirements was not available commercially. Subsequently in 1972, development of the MK 12 SSDS commenced. Diver safety, mobility and and comfort were the basic criteria for the MK 12 SSDS, and the design includes the following features:

General

- State-of-the-art materials and production techniques.
- Complete interchangeability of parts.
- Reduced overall system weight.
- Increased diver safety.

Helmet Assembly

- Reduced helmet noise.
- Increased field of vision.
- Positive and negative buoyancy control.
- Reduced repair time.

Dress Assembly

- Provision of a dry diver envelope.
- Improved diver weight distribution.
- Reduced possibility of diver blowup.
- Improved diver mobility.

- Improved diver comfort within the above constraints.

Support equipment

- Test set.
- Tools.
- Spare parts.
- Welding shield.

With the above features the MK 12 SSDS is a major step forward for the U.S. Navy Salvage Diver. In addition to the above characteristics, the MK 12 system can interface with a wet suit or hot water suit as well as a dry suit for bottom work. Further, the system is more flexible in that appropriate tasks can be performed in a swimming configuration.

1.2 Description. The MK 12 SSDS, air mode, consists of a helmet assembly, a dress assembly and support equipment. The helmet, of fiberglass construction, may be used with either air or mixed gas as the breathing medium. The diving dress includes a dry suit, an outer chafing garment, a jocking harness and weighted diving boots. Two, four and five pound lead weights, to a maximum of 60 pounds, fit into the calf, thigh and hip pockets, respectively, of the outer garment. The hip weights are optional and generally are required when working in shallow water or when using underwater tools. Support equipments consist of a helmet test and spare parts kit, a diving dress repair kit, a deck edge flow meter, and an improved communication/strength cable. For surface/diver communications the MK 12 SSDS interfaces with either the Helle, Model 3315 or the MK 12 Communications Stations (NCSL). Wet suits and swim suits are individual issue items.

1.3 Previous Deficiencies. The first MK 12 SSDS test and evaluation period was in 1973 and is reported in NEDU Interim Report No. 7-74, Technical Evaluation of the Surface Supported Diving System USN MARK XII. The system was found to be superior in every aspect except for mission and life support reliability, which did not meet standards because of the following four areas:

"(a) Availability

(b) Helmet ventilation (ACFM) in the air mode only.

(c) Durability of the constant volume dry suit.

(d) Communications intelligibility (mixed gas mode)."

Specific comments from the report are quoted below:

Helmet

"Exhaust Valve. Simplify to make the valve easier to maintain in the field and at the same time eliminate the possibility of human procedural error which can result in water seepage through the valve. In making this modification, a high level of durability and reliability must be maintained.

"Control Valve. Modify the internal mechanisms of the valve to provide helmet ventilation of no less than 6 ACFM at 250 feet while using air with no greater than 50 psi over bottom pressure for a driving force.

"Communications. Provide permanently mounted quick-disconnect fixtures for communication transceivers.

"Seals. Change helmet/necking seal arrangement to a horizontally mounted O-ring/marmon clamp arrangement. This will ease the helmet donning and doffing procedures as well as reduce the possibility of O-ring failure."

Diver's Dress

"Unisuit. Provide a permanently attached thin (1/8 inch) solid rubber cape inside the Unisuit in areas subject to excessive chafing, such as around the neck and across the shoulders. Except for tearing, this will reduce the possibility of suit leakage.

"Warm Water Suit. Fabricate a lightweight dry constant volume suit to complement the system for use in warm water. This will provide the system with both a cold water dry suit and one to use in warm water.

"Boots. Fabricate weighted rubber diving boots with a full range of sizes rather than a single size as was the case during the T & E period.

Ancillary Equipment

"Tools. Ensure that standard "off-the-shelf" tools can be used throughout for maintaining the system, rather than specially manufactured tools.

"Communications. Continue searching for an improved communications system. This recommendation is made in view of the fact that T & E data clearly points out that the system utilized was only equal, but not superior to the Navy standard system in speech intelligibility."

1.4 Corrective Action. All of the items mentioned above have been corrected except as is noted in the paragraphs which follow, but some of the proposed corrective actions proved to be unsuitable during component development and testing.

1.4.1 Helmet Assembly

Supply Valve (Old Control Valve) Subsequent to the 1973 T & E period, research at NEDU determined that regardless of depth a flow of 6 ACFM was required for CO_2 flushing at the most severe attainable work rates (CO_2 production 3 liters per minute); see NEDU Research Report 16-74 dated 16 July 1974. During the component test and development phase it was determined that the required helmet driving pressure for an air flow of 6 ACFM at depth was from 35 to 50 psig over bottom pressure. To obtain these driving pressures, console over bottom pressure availability was reviewed. It was determined

that console over bottom pressure was a function of internal hose friction (line loss) and gas density. Preliminary tests have demonstrated that console over bottom pressures of 60 psig for a 200 foot umbilical and 100 psig for a 600 foot umbilical provide the required air flows to all depths down to 250 FSW.

Seals (Breech Ring) - The optimum helmet/suit seal system was determined to be a barrel O-ring in the upper (helmet) breech ring with a positive pin latch mechanism.

1.4.2 Dress Assembly

Dry Suit - A dry suit utilizing the same material but of a notably different design than the Unisuit is now being used with the MK 12 SSDS. As indicated in MK 12 SSDS Report No. 6-75, Air Subsystem, Dry Suit Evaluation, the location, contour and bonding of the dry suit seams reduced seam stress and the possibility of seal failure. During TECHEVAL there was no noticeable wearing of the dry suit nor did the seams leak.

Warm Water Suit - After considerable research and developmental effort, it was determined that a lightweight dry suit was not required. The final MK 12 helmet configuration resulted in a helmet that was neutrally buoyant in the water. This feature allows the MK 12 helmet to interface with a neck seal (neck dam) so that the wet suit or swim suit can be used for warm water application and a swimming configuration. With this new flexibility the MK 12 SSDS family of diving dress can include swim suit, wet suit, hotwater suit and dry suit, which meets all temperature requirements of a surface supported diving system.

1.4.3 Communications

Communications Station - A communications station has been developed by NCSL which appears to meet MK 12 SSDS requirements. Presently identified as the MK 12 Communications Station, this unit was used in TECHEVAL and will be used in OPEVAL. Further word intelligibility testing will be required for both the air and mixed gas modes.

Helmet Quick Connect - The electrical harness in the helmet was modified so that plug-in connectors are used for both earphones (transceivers) and the microphone.

1.5 Evaluation. The technical evaluation, operational phase, of the MK 12 SSDS, air mode, Advanced Development Model (ADM) is outlined in NEDU's TECHEVAL Test Plan Project T/S 283, dated December 1975.

Section 2

MANNED TEST RESULTS

2.1 General. The MK 12 SSDS, air mode, was tested in two configurations: (1) the dry suit with the adjustable helmet exhaust valve, and (2) the wet suit with the ambient helmet exhaust valve.

2.1.1 Dives were conducted at the water front, east pier, NCSL (59 dives); the OSF wet chamber, NEDU (26 dives); and Stage II, Gulf of Mexico (191 dives) for a total of 276 dives. Training was conducted in the NEDU equipment test pool and at the NCSL pier and included 132 dives. Altogether, a total of 408 dives was made in the MK 12 during TECHEVAL. Although training dives will not be included in the data collected and reported herein, it is worthy of mention that there were no material failures or dive aborts during the training period. Upper and lower temperature testing was conducted separately, and the dive totals for this phase are not included above.

2.1.2 The total number of divers involved was twenty-seven; twelve from NEDU and fifteen from various fleet units. However, the MK 12 team, comprised of one Officer, three Chief Petty Officers and one Master Diver, all made occasional dives. A standby diver in the ready status (MK-1 Bandmask) was maintained for each dive.

2.1.3 Test procedures were varied as follows:

(1) Bottom times were increased/decreased as task, weather, and time dictated.

(2) Tasks were changed as tools and equipment were available and were time dependent.

(3) When appropriate, an equal number of dives was performed in each configuration.

2.2 Summary Results. Summary results of TECHEVAL diving are shown in Tables 2-1, 2-2 and 2-3.

TABLE 2-1

MK 12 SSDS

TECHEVAL DIVING SUMMARY

Total TECHEVAL dives			- 276
Dry suit		- 154	
Tool	- 42		
Max. Limits	- 16		
Reliability	- 96		
Wet suit		- 122	
Tool	- 17		
Max. Limits	- 10		
Reliability	- 95		
Total training dives			- 147
NEDU MK 12		- 72	
Fleet Divers		- 75	
MK 12	- 60		
MK V	- 15		
Total ALL dives			- 423
MK 12		- 408	
MK V		- 15	
Total aborts			- None

TABLE 2-2

MK 12 SSDS

TECHEVAL SUMMARY RESULTS
OPERATIONAL AND TECHNICAL

Operational Characteristics	MK 12 Developmental Objectives	TECHEVAL Results
Normal Working Dive Limit (NWDL)	200 FSW 1/	200 FSW
Maximum Dive Limit	250 FSW	250 FSW 2/
Total Time of Dive Limit	5 hours	5 hours
Lower Temperature Limit	29° F	27.8° F 3/
Higher Temperature Limit	120° F	120° F 3/
Sea State	4	4
Maximum Water Current	2 kts.	1.5 kts. 4/
Noise Level	<90 dbA	<90 dbA
CO_2 Ventilation, Surface Equivalent	Max. 2%	1.6%
Flow Capability at All Depths	6 ACFM	6 ACFM

NOTES:

1/ SOR 46-54 states NWDL as 200 FSW; the Diving Manual states NWDL is 190 FSW. This latter value is the acceptable normal working dive limit.

2/ The system was tested successfully during the unmanned tests to 300 FSW.

3/ Unmanned testing. Manned diving was limited in the lower temperature range to 35° F by a cooling equipment malfunction and in the upper temperature range to 93° F by order of the NEDU Senior Medical Officer.

4/ Limited by sea conditions prevalent during the test period.

Technical Characteristics	MK 12 Developmental Objectives	TECHEVAL Results
Life Support Reliability (R_L)	$\geq$0.975	0.989 1/
Confidence	95%	95%
Mission Reliability (R_M)	$\geq$0.90	0.992 1/
Confidence	90%	90%
Operational Availability (A_O)	$\geq$0.75	0.903 2/
Confidence	90%	90%
Reaction Time (T_R)	<30 min.	19.9 min.
Turnaround Time (T_T)	<20 min.	7.4 min.
Mean Time to Repair (MTTR)	< 4 hrs.	0.22 hrs.

NOTES:

1/ 276 dives with no aborts.

2/ Demand usage time, 146.7 hours; downtime, 10.7 hours.

TABLE 2-3

TECHEVAL SUMMARY RESULTS

PHYSICAL

Physical Characteristics

Buoyancy

Required. The system, when manned, is to be neutrally buoyant with minimum weight addition under normal operating conditions. Diver buoyancy control, both positive and negative, is required.

Actual. The MK 12 SSDS (air mode) has proved to be neutrally buoyant with weight variations determined by diver preference. All TECHEVAL divers were able to demonstrate buoyancy control, both positive and negative. Some divers developed skills to provide very fine vertical positioning (hovering).

Weight

Required. Dry weight of the system should be minimized. A system dry weight of less than 115 pounds in the operational air mode is desirable.

Actual. The basic MK 12 SSDS (air mode) dry weight is 100 pounds including normal diver weights of 40 pounds. This weight is approximately half the MK V (air mode) dry weight of 195 pounds.

Envelope Dimensions

Required. The diver, when fully dressed, will be able to pass through submarine and dive system hatches or climb, unassisted, through a cylindrical trunk 30 inches deep and 24 inches in diameter.

Actual. This has been successfully demonstrated in the air mode.

2.3 Test 0-1: Suitability.

2.3.1 Purpose. To determine the operational suitability of the MK 12 SSDS to support a working diver from the surface to depth. For purposes of the TECHEVAL, major equipment failures were defined as failures which could cause (1) an abort, (2) serious injury to divers or tenders, or (3) reduced system operational capability. All other failures were considered minor.

2.3.2 Data Analysis and Results.

Total dives considered, test 0-1	- 276
Dry suit/adjustable exhaust valve	- 154 dives
Wet suit/ambient exhaust valve	- 122 dives
Average bottom time	- 13.8 min.
Average total dive time	- 21.9 min.
Aborts	- 0
Equipment failures	
Major	
Helmet (None)	- 0
Dress	
Jocking harness (tripped underwater)	- 2
Support (None)	- 0
Major Total	2
Minor	
Helmet	
Microphone failure	- 1
Communications whip leaked	- 3
Air whip leaked	- 3
Exhaust valve, improper assembly caused leaks	- 1
	8
Dress	
Suit breech ring lug, adjustment	- 11
Dry suit, pin hole leak	- 1
Dry suit, zipper failed	- 1
	13

Support	
Comm./strength cable, protective cover shredded	- 2
Minor Total	23
Total Failures	25

2.3.3 <u>Reliability</u>. Both Life Support (R_L) and Mission (R_M) Reliability were considered for the total system dives during TECHEVAL as well as the total dives in each of the two diving dress configurations.

<u>Standard</u>

	Reliability	Confidence	No. dives
R_L	0.975	95%	120 with no aborts
R_M	0.900	90%	120 with 7 aborts

<u>TECHEVAL</u>

System:

R_L	0.989	95%	276 with no aborts
R_M	0.992	90%	276 with no aborts

Dry suit/adjustable exhaust valve:

R_L	0.981	95%	154 with no aborts
R_M	0.985	90%	154 with no aborts

Dry suit/ambient exhaust valve:

R_L	0.976	95%	122 with no aborts
R_M	0.981	90%	122 with no aborts

2.3.4 Turnaround Time (T_T). No attempt was made during diving operations to expedite turnaround time. However, in most cases the next diver was completely dressed and needed only to don the helmet used in the previous dive to commence the next dive. With divers that are experienced in the use of the MK 12 SSDS, turnaround time can be reduced to seconds.

The T_T average (mean) for the total 276 dive missions includes down time and repair time.

T_T (mean) = 7.4 minutes

T_T (minimum) = 1.0 minute 1/

1/ On numerous occasions T_T was less than one minute.

2.3.5 Reaction Time (T_R). The initial set up and pre-dive checks were conducted slowly and thoroughly to instruct new personnel in the proper use of the MK 12 helmet test set.

T_R (mean) = 19.9 minutes

T_R (minimum) = 6.0 minutes 1/

1/ This time was established by MK 12 development personnel, who were very familiar with the MK 12 system and procedures.

2.3.6 Diver Efficiency. On-site interviews and post-TECHEVAL Human Engineering Data Sheets provided a subjective appraisal of diver efficiency attainable with the MK 12. (See Section 2.10).

2.3.7 Communications. Two diver communication stations were evaluated during the TECHEVAL: The NCSL-developed MK 12 Communication Station and the Helle Model 3315.

The MK 12 Communications station has several advantages. The station permits party line communications between up to three divers and the topside tender. The standby diver may use either a MK 12 helmet or a MK-1 bandmask. Power output (5 watts) is high, approximately twice as powerful as the Helle station, which means strong, positive communications. Finally, the system is equipped with a head set which permits the tender to remain in the vicinity of the diving supervisor.

The Helle Communications Station by comparison has low output power, has no party line capability, and requires the tender to remain at the station. The Helle station is compatible with MK 12 SSDS, but the quality of performance of the Helle was poor when compared with the MK 12 SSDS Communications Stations (NCSL).

2.3.8 Donning/Doffing. During dry suit evaluations conducted in November 1975, Dry Suit donning time averaged 1.6 minutes and doffing averaged 0.55 minute. During TECHEVAL the next diver was usually dressed, except for the helmet, waiting for the previous diver to complete his dive. In the instances that donning/doffing was timed, donning averaged 4.1 minutes and doffing averaged 2.1 minutes. It should be noted that the TECHEVAL dry suits were not properly sized and were excessively tight in fit. Recently acquired suits are properly sized and will likely result in improved donning and doffing times.

Timed surface decompression (Sur-D) procedures were exercised. This evolution was timed from leaving 40 feet of water to the surface, undressing the diver and escorting him to the chamber.

Sur-D, Average - 2.2 minutes

Sur-D, Minimum - 1.6 minutes

2.4 Test M-1: Reliability

2.4.1 Purpose. The purpose of this test was to evaluate the material reliability of the MK 12 SSDS.

2.4.2 Data Analysis and Results. Mean Time Between Failure (MTBF) for each MK 12 system used in TECHEVAL was computed using the total operating time divided by the total number of major failures occurring during this period. The confidence limit was computed for the system as a whole.

MK 12 System ADM #003 - Operational Time/Failures

72.4 hrs/1 = 72.4 hrs

MK 12 System ADM #006 - Operational Time/Failures

70.5 hrs/1 = 70.5 hrs

MK 12 EX #2 - Operational Time/Failures

3.8 hrs/1* = 3.8 hrs

All Operational Time/Failures

146.7/2* = 73.4 hrs

MTBF at 90% confidence = 28.3 hours

No major failures occurred during pre-dive or post-dive checkout periods. Both major failures occurred when the diving systems were in the water, and neither of these failures are the type which can be detected during pre-dive checks. None of the failures were in the life support systems or resulted in a mission abort.

* Only 2 major failures occured during TECHEVAL. MK 12 EX # 2 helmet was used briefly as indicated with no failures, but division by zero provides meaningless data.

2.5 Test M-2: Maintainability

2.5.1 Purpose. The purpose of this test was to evaluate the maintainability of the MK 12 SSDS.

2.5.2 Data Analysis and Results. There were no critical equipment failures during TECHEVAL. The major failures occurring during TECHEVAL did not result in a dive abort, but these failures could, in the proper circumstances, contribute to or result in an abort situation.

Failure	Probable Cause	Corrective Action
Jocking Harness (2)	Diver exertion caused the harness to come unlatched	1. Diving partner assisted in re-latching harness. 2. Commenced redesign of latch to ensure positive lock.

Mean Time To Repair (MTTR). This factor includes Mean Time to Fault Locate (MTFL) by definition.

Failure	Fault Locate Time (hours)	Repair Time (hours)	Part Number
Major, Jocking Harness (2)	0.2	0.2	N/A
Minor Items (23)	2.4	5.2	N/A

$$\underset{\text{(Major)}}{\text{MTFL}} = \frac{0.2}{2} = 0.1 \text{ hrs.} \qquad \underset{\text{(Major)}}{\text{MTTR}} = \frac{0.2}{2} = 0.1 \text{ hrs.}$$

$$\underset{\text{(Minor)}}{\text{MTFL}} = \frac{2.4}{2.3} = 0.10 \text{ hrs.} \qquad \underset{\text{(Minor)}}{\text{MTTR}} = \frac{5.2}{23} = 0.23 \text{ hrs.}$$

$$\underset{\text{(All)}}{\text{MTFL}} = \frac{2.6}{25} = 0.10 \text{ hrs.}$$

$$\underset{\text{(All)}}{\text{MTTR}} = \frac{5.4}{25} = 0.22 \text{ hrs.}$$

TOTAL CHECK-OUT TIME. The total check-out time, pre-dive and post-dive, was 6 hours 54 minutes.

Time per dive:

$$\frac{414 \text{ minutes}}{276 \text{ dives}} = 1.5 \text{ min. per dive}$$

Average check-out time per diving day:

$$\frac{414 \text{ minutes}}{16 \text{ diving days}} = 25.9 \text{ min. per day.}$$

MAINTAINABILITY COMMENTS

a. Test Set. The test set proved functional and adequate. However, due to a change in the helmet pre-dive procedures following TECHEVAL, the present 0-15 psi gauge, used in the relief valve test, will be replaced by a 0-30 psi gauge for OPEVAL.

b. Safety Hazards. No safety hazards were encountered during TECHEVAL.

c. Equipment Receipt Condition: Excellent.

d. Equipment Maintenance Time: Average daily repair time - 0.32 hrs. Average daily reaction time - 0.35 hrs. Daily total - 0.7 hrs. TECHEVAL total - 10.7 hrs.

e. Special Tools or Material Required. None.

f. Condition of Spares Upon Receipt: Excellent.

g. Training. The formal training for NEDU and Fleet divers was considered adequate to permit individuals, without supervision, to perform MK 12 maintenance properly and quickly. The only instance of repairs required, beyond the capability of the assigned personnel, was the dry suit zipper replacement.

h. Safety Devices. During TECHEVAL all safety devices performed as designed.

1. Air Supply Non-Return Valve. Although adequate, a change is under consideration to standardize Navy non-return valves.

2. Air Supply Relief Valve. On the surface and at near surface depths the valve will lift when excessive flow is forced through the air supply system. When the valve lifted, there was no noticeable change in helmet noise nor was an air draft detected on the face.

3. Diaphragm, Exhaust Valve. The diaphragm in the exhaust valve is a one-way valve to reduce the possibility of helmet flooding in certain helmet attitudes.

4. Electrical Devices. When using the MK 12 SSDS Communications Station (NCSL) 8 milliamps at 20 volts d.c. are sent to the microphone preamplifier in the helmet. Even when wet, this poses no hazard to the diver.

i. Maintenance Difficulties. None existed during TECHEVAL.

j. Pertinent Maintainability Factors: The MK 12 is a very easy system to work on, correct and maintain. Troubleshooting is normally an obvious deduction.

2.6 Test M-3: Operational Availability (A_O)

2.6.1 Purpose. To determine the probability that the MK 12 SSDS will be operationally ready, when needed, at any point in time.

2.6.2 Data Analysis and Results. Operational availability is computed using demand usage time divided by demand usage time plus downtime. Demand usage time is that time during which the equipment can be operated to minimum specified standards. Downtime is the total time resulting from all maintenance actions and from administrative and logistic maintenance delays.

Standard

A_O = 0.75 w/90% confidence

Actual

$$A_O = \frac{146.7}{157.4} = 0.932$$

A_O = 0.903 w/90% confidence

2.7 Test M-4: Compatibility

2.7.1 Purpose. The purpose of this test is to determine the compatibility of the MK 12 SSDS with support equipment and the physical environment.

2.7.2 Data Analysis and Results. The following was obtained by observing the effects of interfacing the MK 12 SSDS with associated equipment and the operating environment.

- During TECHEVAL there were no detected effects on the MK 12 SSDS due to shock or vibration.

- The helmet air adapter is being modified to accommodate a barrel O-ring fitting on the air hose whip (leader) thereby eliminating a source of air leakage.

- The helmet communications cable adapter has been changed to the barrel O-ring type to eliminate a possible source of leakage.

- In a heavy sea near the surface the MK 12 is quite light. However, it is easily controlled by the diver.

- When the microphone becomes wet, there can be a severe attenuation of diver to surface communication, especially in the wet suit configuration when a neck dam is used. However, by blowing on the microphone, thereby displacing the water from the diaphragm, this problem is resolved easily, even at depth.

- The design of the quick release buckle on the jocking harness has been changed to eliminate the possibility of inadvertent release.

- The lens coating on the welding shield cannot withstand salt water for prolonged periods of time. The coating will deteriorate, especially about the edges. Correction of this problem is being investigated.

2.8 Test M-5: Supportability

2.8.1 Purpose. The purpose of this test is to assess the supportability of the MK 12 SSDS in the operational environment. This test consists of evaluating the actual logistic support available and exhibited during TECHEVAL.

2.8.2 Data Analysis and Results. The one instance of supply downtime involved the No. 2 prototype (EX #2) helmet that was delivered to the dive site without a complete set of spares. The failure that resulted from this oversight was neither critical nor major, but it did create the only supply downtime situation. It is noted that the EX #2 helmet was used only during part of one day of TECHEVAL while ADM #006 helmet was being modified to accommodate the Kintec electrical fitting.

LOGISTIC SUPPORT INDEX

The Logistic Support Index (LSI) is computed by dividing the total supply downtime by the number of critical and major failures experienced with the MK 12 SSDS.

Although the failure was less than major, a small leak in the exhaust valve did occur because of the situation stated above, and spares were not immediately available.

$$\frac{\text{Total Supply Downtime}}{\text{No. of Failures}} = \frac{1.6 \text{ hrs}}{1} = 1.6$$

In view of the above, insufficient data is available to determine a meaningful LSI. However, the spare parts available were adequate to permit timely and proper maintenance, both corrective and preventative.

2.9 Test M-6: Technical Documentation

2.9.1 Purpose. The purpose of this test was to evaluate the adequacy of the Operations and Maintenance (O & M) manual, and other printed maintenance aids.

2.9.2 Data Analysis and Results. The O & M manual required some modification due to changes in procedures, system design and associated equipment. In general, however, the manual was complete and useful for the operational maintenance of the MK 12 SSDS, air mode.

Nearly every diver remarked about the need for more time to adequately assess the manual.

The younger, less experienced divers relied more on the manual than the others. A requirement exists for formal training in the MK 12 SSDS prior to actual use of the system.

Additional photographs are desired by the divers to better illustrate the manual text.

The existing manual is easy to read and understand. The terms, acronyms and abbreviations were clearly understood.

The system checks and tests and their procedures were considered adequate without change.

2.10 Test H-1: Operating Equipment

2.10.1 Purpose. To assess the adequacy with which the equipment was designed to provide a work environment that fosters effective procedures, personnel safety and which minimizes discomfort, distraction and any other factor that degrades human performance or increases error.

2.10.2 Data Analysis and Results. Human engineering questionnaires were completed after the initial dives and at the end of the diving period by both NEDU and Fleet divers. In the sections below, pertinent diver comment is summarized and evaluated. It is noted that these comments are directed at deficiencies and that diver acceptance of the MK 12 SSDS air mode was enthusiastic. In the final debriefing of the Fleet divers, 14 of the 15 divers agreed that given a choice they would prefer the MK 12 SSDS over the USN MK 1 Bandmask for any given underwater task.

2.10.2.1 Design for operation

Helmet Assembly

a. Noise Level. Two divers commented on instances of high helmet noise level. In unmanned testing, the single major discrepancy of the MK 12 helmet was the excessive noise level at depths greater than 100 FSW. A new helmet liner material and an improved air supply diffuser have been incorporated into the helmets and have reduced the surface helmet noise level by 9 dbA. This should result in acceptable noise level at all depths for a typical mission profile. In operation, however, the noise level was not considered disturbing by the divers, and communications were generally excellent throughout TECHEVAL.

b. Exhaust Valve. On two occasions the chin button pulled off the poppet shaft, and several divers commented that the plastic chin button was unsatisfactory. The chin button has been redesigned for future procurement.

c. Breech Ring Latch Mechanism. On several occasions the breech ring latch was difficult to release, due to a slight misalignment of the suit breech ring lugs. The hole diameter on the breech ring lugs was increased to allow for slight misalignments. In addition, the lugs have been beefed up to increase durability. These two corrective actions have solved the interference and misalignment problems in this area.

d. Side Viewports. Three divers objected to the distortion inherent in viewing through the side viewports. When moving the eyes from the front viewport to the side, the scene appears to move. While this phenomenon was initially distracting, most divers became accustomed to the side viewports very quickly. These viewports allow

additional light into the helmet and provide good peripheral vision. The advantages are considered to far outweigh the distortion disadvantage.

e. Stability. Initially a few divers complained that the helmet slipped forward when the divers were bending over. On analysis, in each instance it was determined that the helmet was improperly jocked down into position.

Dress Assembly

a. Dry Suit Sizing. Several divers commented about the dry suit being sized too small. The dry suits used during TECHEVAL were not sized for the U.S. Navy diver population. This required a one size down grading for all of the dry suits, i.e. medium became small, large became medium, etc. In the dry suits procured for OPEVAL, this discrepancy has been corrected.

b. Boot Sizing. A few divers complained about boot fit. Two types of off-the-shelf boot were evaluated during TECHEVAL, and in general, the boots were too narrow and poorly sized. This problem will be corrected for OPEVAL.

c. Weights. The divers agreed unanimously that the MK 12 must have additional weight for certain tasks or water conditions. Consequently, hip weight pockets for four 5 pound weights have been designed into the outer garment to correct this problem. All divers commented favorably upon weight location, low in the thigh and calf areas.

Support Equipment

a. Communication Cable/Strength Member Covering. On two occasions the polyurethane jacket covering the cable was severely cut by barnacles. This is the first recorded instance of damage to this coating in four years of MK 12 diving. Careful reevaluation as to the suitability of this cable is being conducted, and it is likely that a substitute cable will be required.

b. New Standard Navy Hose. This hose, MIL-H-2815E, was popular with both divers and tenders. Several divers commented that the hose could be kinked more easily than the older hose, but this did not cause problems operationally. The hose was subjected to the same barnacles mentioned above with only minor abrasion damage.

2.10.2.2 Design for Maintainability

Helmet Assembly

a. General. The divers had no adverse comments on the maintenance of the helmet and its components.

b. Metal Finish. The black chrome coating used on all external metal surfaces was satisfactory. However, in some high wear areas it deteriorated, i.e., supply and exhaust valve handles. A new metal finishing technique called Impreglon™ is being investigated. Initial tests of Impreglon™ treated metals have shown exceptional resistance to electrolysis while providing an anti-friction, anti-corrosion surface.

Dress Assembly

a. General. The entire dress assembly proved very durable during TECHEVAL and required a minimum of maintenance.

b. Dry Suit. One small leak occurred at the back of the neck. This was a small pin hole leak that did not affect the dive and was easily repaired upon surfacing with a thermal plastic repair stick. In addition, one zipper failed during dressing.

2.10.2.3 Testing Equipment. The only piece of system test equipment, the helmet test set, operated satisfactorily during TECHEVAL.

2.10.2.4 Communications

a. Communications Station. During TECHEVAL two Communications Stations were evaluated, the Helle Model 3315 and the MK 12 station (NCSL). The NCSL station was far more popular with the divers since party line communication was possible, and the amplification was significantly higher with less distortion. In addition, the NCSL station was equipped with a remote headset which allowed the tender to remain in the vicinity of the diving supervisor. Word intelligibility tests will be performed in June 1976.

b. Microphone. One helmet microphone failed and required replacement. The mount proved unsatisfactory, and a new mount has been provided for OPEVAL.

2.10.2.5 Environmental Conditions

Helmet Assembly

a. Air, Electrical and Mixed Gas Adapters. The compression O-ring seals used in these adapters leaked when not adequately tightened down and were responsible for some down time during TECHEVAL. These adapters have been redesigned to barrel O-ring seals which should eliminate this problem.

Support Equipment

a. Welding Shield. The gold coating on the welding lenses peeled and flaked during the underwater tool testing. A modified lens is being investigated.

2.10.2.6 Hazards and Safety

Helmet Assembly

a. Supply Valve. A few divers commented that it may be possible to jam the supply valve in the shut position. After a review it was concluded that the chance of this failure was extremely unlikely, that a constant bleed valve was not required, and that the original design was adequate.

b. Flow. Three divers considered that helmet air flow was insufficient and that the system as designed could cause CO_2 buildup. In each case an examination of the dive profile and the diver's techniques determined that there was no failure in the MK 12 system. Rather, through diver inexperience or neglect, flow was low because the supply valve had not been opened sufficiently to properly flush the helmet.

Dress Assembly

a. Jocking Harness Latch Mechanism. The harness latch mechanism became unfastened underwater in two instances either due to diver exertion or by snagging on an obstruction. A positive securing device for the latch has been designed for use during OPEVAL.

b. Jocking Harness. Several divers recommended that the bitter ends of the harness straps be fastened down. This is particularly desirable when using underwater rotary tools. A review of the problem determined that the strap ends should be tucked into the harness.

2.11 Test H-2: Personnel and Training Requirements

2.11.1 Purpose: To determine whether the divers' state of training is adequate to enable them to operate and maintain the MK 12 SSDS.

2.11.2 Data Analysis and Results: Operational Training. The following responses were recorded on the "Operating (Diving) Training Assessment Questionnaire." Since the response to the questionnaire was overwhelmingly "satisfactory" throughout the range of personnel aspects observed, the questions are not summarized by aspect as outlined in the test plan.

Question:

1. Can you satisfactorily operate the MK 12 diving system?

   Response: 100% Yes.

2. Do you have confidence in the performance of this system?

   Response: 100% Yes.

3. Would you have been able to operate the MK 12 Diving System without formal training?

   Response: 84% Yes. 16% No.

   Comment: The negative comments were from less experienced divers with one exception. They felt unfamiliar with the equipment and that the operational training was necessary. One veteran diver commented "you must learn before you dive." These are valid comments, since the MK 12 SSDS is significantly different from the MK V and does require adequate crossover training.

4. Did you have any difficulty deciding what action was necessary in order to properly use the MK 12 Diving System?

   Response: 100% No.

5. Did you have any difficulty in using the communications support equipment?

   Response: 100% No.

6. Is there any specific knowledge not covered in the formal training that you found you needed in order to operate the equipment?

   Response: 100% No.

7. Do you believe that your MK 12 SSDS operational training on the equipment is adequate?

   Response: 100% Yes.

8. Do you believe that your MK 12 diving system training is adequate for you to cope with emergency situations?

Response: 92% Yes. 8% No.

Comment: The only emergency training covered was Sur-D procedures. However, two instances of the jocking harness quick release buckle being accidentally opened at depth did not result in diver or dive partner anxiety. The divers corrected the situation and continued with their tasks.

9. Are your techniques for operating the MK 12 dive system different from those taught?

Response: 100% No.

10. Are your techniques for operating the MK 12 dive system different than those shown in the technical manual?

Response: 100% No.

11. Are there any conditions under which you consider the MK 12 too tiring (fatiguing) to operate?

Response: 100% No.

12. What changes would you make to your formal training?

Response: 84% None. 16% comments below.

Comment: "Longer working dives, under more severe conditions, and more time with underwater tools," is summation of the comments.

13. Additional comments you consider pertinent to the MK 12.

Response: The general consensus indicates the divers consider the MK 12 far superior to the MK V. Fourteen of fifteen Fleet divers would prefer the MK 12 to the USN MK 1 Bandmask if they were both available for the same job.

2.11.3 Data Analysis and Results: Maintenance Training. The following responses were recorded on the "Maintenance Training Assessment Questionnaire." The answers to these questionnaires were, also, almost all satisfactory regardless of personnel aspect, and the answers are not summarized by aspect as outlined in the test plan. In the two questions which did not meet satisfactory criteria, individual differences related to personnel aspects will be reviewed in the comments.

Question:

1. Do you consider your maintenance training adequate to effectively fault detect on the MK 12 equipment?

Response: 100% Yes.

2. Do you consider your maintenance training adequate to effectively fault locate on the MK 12 equipment?

   Response: 100% Yes.

3. Do you consider your maintenance training adequate for the parts removal, repair, and replacement work necessary for the MK 12 equipment?

   Response: 100% Yes.

4. Do you consider your maintenance training to be adequate to enable you to perform the calibrations required on the MK 12 equipment?

   Response: 100% Yes.

5. Do you consider your maintenance training to be adequate to perform system check tests required for the MK 12 equipment?

   Response: 100% Yes.

6. Without formal schooling on the MK 12 equipment, would your Navy diving experience have been adequate to enable you to satisfactorily fault detect, fault locate for this system?

   Response: 58% Yes. 42% No.

   Comment: All negative responses considered that some formal training is required, even with the technical manual available. In general, a negative answer indicated a lack of familiarity with new concepts introduced in the MK 12 system. The negative response was from those divers with less experience, those whose operational experience was limited to MK V equipment, and those with experience but cautious in their approach to new equipment.

7. Without formal schooling on the MK 12 equipment, would your Navy diving experience have been adequate to enable you to cope with the parts removal, repair and replacement work necessary for the system?

   Response: 58% Yes. 42% No.

   Comment: The same men made negative comments as on question No. 6 above. Again, they considered that there was a need to familiarize themselves with the new parts and components within the MK 12 system.

8. Without formal schooling on the MK 12 equipment, would your Navy diving experience have been adequate for you to understand the calibration procedures associated with this system?

   Response: 84% Yes. 16% No.

Comment: Again some of the same divers saw a need for formal schooling when dealing with the adjustable valves.

9. Without formal schooling on the MK 12 equipment, would your Navy diving experience have been adequate to enable you to grasp the equipment checkout test procedures?

Response: 84% Yes. 16% No.

Comment: The same divers indicated that some schooling was required.

10. Do you find the fault detection/fault locate procedures difficult to understand and/or follow?

Response: 100% No.

11. Do you find the parts removal, repair and/or replacement procedures to be difficult to understand and/or follow?

Response: 100% No.

12. Do you find the calibration procedures common to this system difficult to understand and/or follow?

Response: 100% No.

13. Do you find the equipment check-out lists to be difficult to perform or to understand?

Response: 100% No.

14. Did you find the formal maintenance schooling difficult to grasp and/or understand?

Response: 100% No.

15. Is there any specific knowledge not given you in the formal training that must be acquired in order to fault detect/fault locate in the MK 12 system?

Response: 100% No.

16. Is there any specific knowledge not given in formal training that must be acquired in order to correctly remove, repair and/or replace parts in the MK 12 system?

Response: 100% No.

17. Is there any specific skill that you must acquire in order to correctly remove, repair and/or replace parts in the MK 12 system?

Response: 100% No.

18. Do the parts removal, repair and/or replacement procedures that you use differ from those recommended in the:

a. Formal Training:

Response: 92% No. 8% Yes.

Comment: The negative response related to the availability of tools. In fact, tools were on station but not always at the affected diver's bench.

b. Technical Manual:

Response: 92% No. 8% Yes.

Comment: The affirmative response was from the same diver in 18.a above and related to the immediate availability of the manual at his station. The manual was on station.

19. Do the checkout procedures that you use differ from those recommended in the:

a. Formal Training:

Response: 100% No.

b. Technical Manual:

Response: 100% No.

20. Did you receive any contractor/development personnel assistance while fault detection/fault locating the MK 12 system?

Response: 100% No.

21. What changes would you like to have made to your formal (school) maintenance training on the MK 12 system?

Response: 100% None.

Comment: However, one diver would prefer to have more training.

22. Make any additional maintenance comments that you consider pertinent to the MK 12 SSDS that have not been covered.

Response: 100% None.

2.11.4 SUMMARY

The divers were confident in their ability to operate and maintain the MK 12 SSDS air mode. They prefer the MK 12 system to other diving equipments.

The brief training period was considered adequate by the majority, but the less experienced divers preferred to have more formal instruction on the MK 12 system.

Section 3

UNMANNED TESTS

3.1 General. This test series was designed to demonstrate that the physical characteristics of the MK 12 SSDS air mode meet the required operational characteristics for a Surface Supported Diving System.

3.1.1 Location. These tests were performed in the NEDU Ocean Simulation Facility (OSF), Panama City, Florida, and conducted during the period 19-28 January 1976. Additional tests to ensure that minor, post-TECHEVAL modifications to the system meet requirements were conducted in the NCSL Hydrospace Laboratory from 17-28 May 1976.

3.1.2 Personnel. NEDU Test and Evaluation personnel performed the required tests, assisted by MK 12 project personnel.

3.2 Scope of Testing.

3.2.1 Conduct. This test series was conducted in accordance with Table A-3 and Appendix I to Annex A of the TECHEVAL Test Plan, MARK 12 Surface Supported Diving System, T/S 283.

3.2.2 Specific Tests. Using the final helmet configuration with the new helmet liner and gas diffuser, the following characteristics were measured during unmanned testing:

Flow - (1) Confirm system air flow is at least 6 ACFM at all depths to 250 FSW.

(2) Determine supply valve settings for flows of 2, 4 and 6 ACFM at selected depths to 300 FSW.

(3) Obtain maximum air flow at 300 FSW.

Δ P - Measure helmet ΔP at selected depths to a maximum of 300 FSW with air flows of 2, 4 and 6 ACFM and with a range of exhaust settings from open to closed.

Ventilation - Confirm that surface equivalent CO_2 level is less than 2.0% at selected depths to a maximum of 250 FSW.

Noise Level - (1) Confirm that helmet noise level at all depths to a maximum of 250 FSW meets the current noise level standard (90 dbA).

(2) Obtain noise level data in the several frequency bands at selected depths to a maximum of 250 FSW.

3.3 Results.

3.3.1 Flow - (1) Flow of 6 ACFM was obtained to 250 FSW.

(2) Flow tabulations are shown in the following Figures:

Figure 3-1 - Supply Valve Position vs. Depth - 200 ft. Umbilical.
Figure 3-2 - Supply Valve Position vs. Depth - 600 ft. Umbilical.

(3) Maximum flow at 300 FSW - 5.79 ACFM.

3.3.2 Δp - (1) The designed helmet ΔP range is 0.3 - 2.0 psid on the surface at 6 ACFM. Test results at 200 FSW are:

Flow (ACFM)	Exhaust Valve (Position)	ΔP (psid)
2	Open	0.19
2	Closed	1.89
4	Open	0.27
4	Closed	2.10
6	Open	0.43
6	Closed	2.30

(2) ΔP tabulations are shown in the following Figures:

Figure 3-3 - Helmet Δp vs. Depth, 6 ACFM.
Figure 3-4 - Helmet Δp vs. Depth, 4 ACFM.
Figure 3-5 - Helmet Δp vs. Depth, 2 ACFM.

3.3.3 Ventilation - Flows of both 4 and 6 ACFM resulted in CO_2 flushing sufficient to hold the surface equivalent (S.E.) CO_2 level to less than 2.0% as shown in Figure 3-6. It is noted that CO_2 production was 2 liters per minute (LPM) with 25 breaths per minute (BPM) at 4 ACFM and 3 LPM with 35 BPM at 6 ACFM.

3.3.4 Noise Level - (1) The 90 dbA Navy standard for noise level is based upon the OSHA industrial standard, i.e., work can be performed at this noise level for eight hours without hearing damage. The MK 12 SSDS air mode met this standard from the surface to a depth of 100 FSW. Below 100 FSW noise levels were high in the mid-frequency range (500-8,000 hertz), which resulted in dbA levels of 95 dbA at 200 FSW and 105 dbA at 300 FSW. While these levels are in excess of the standard, the time at these depths is generally brief, which mitigates the effect of the exposure. Virtually all decompression time will be performed at depths less than 100 FSW. From a practical point of view all MK 12 SSDS air mode diving will fall well within acceptable OSHA sound levels.

(2) Noise level tabulations are shown in the following Figures:

Figure 3-7 - Helmet Noise Level vs. Frequency, 6 ACFM.
Figure 3-8 - Helmet Noise Level vs. Frequency, 4 ACFM.
Figure 3-9 - Helmet Noise Level vs. Frequency, 2 ACFM.

3.4 Conclusions

3.4.1 General. The MK 12 SSDS meets required helmet flow, ΔP and CO_2 ventilation standards at all depths and the noise level requirement to 100 FSW.

21 MAY 1976

MK 12 SSDS - TECHEVAL
SUPPLY VALVE POSITION vs. DEPTH
200 FT. UMBILICAL

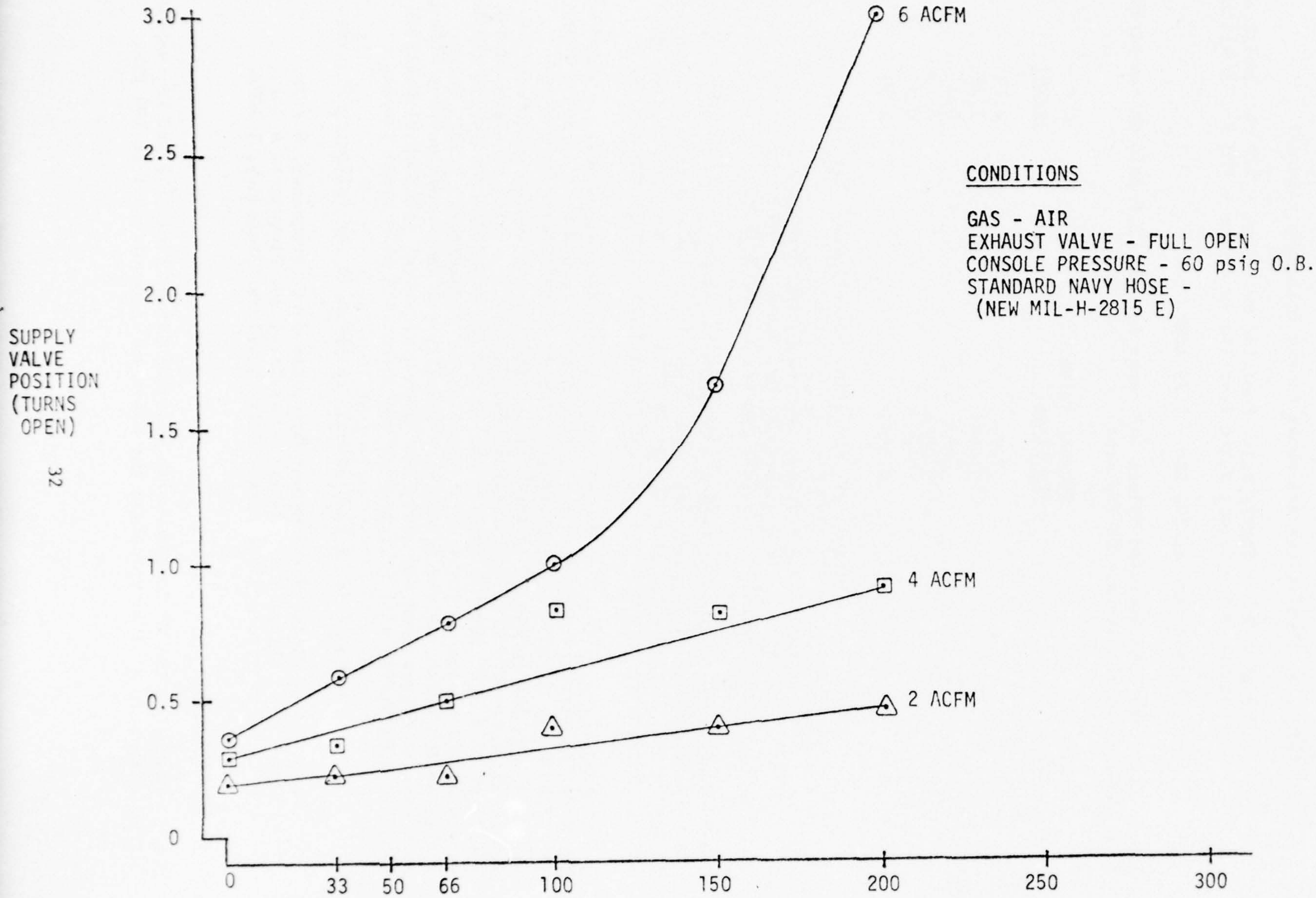


FIGURE 3-1

MK 12 SSDS - TECHEVAL
SUPPLY VALVE POSITION vs. DEPTH
600 FT. UMBILICAL

21 - 24 MAY 1976

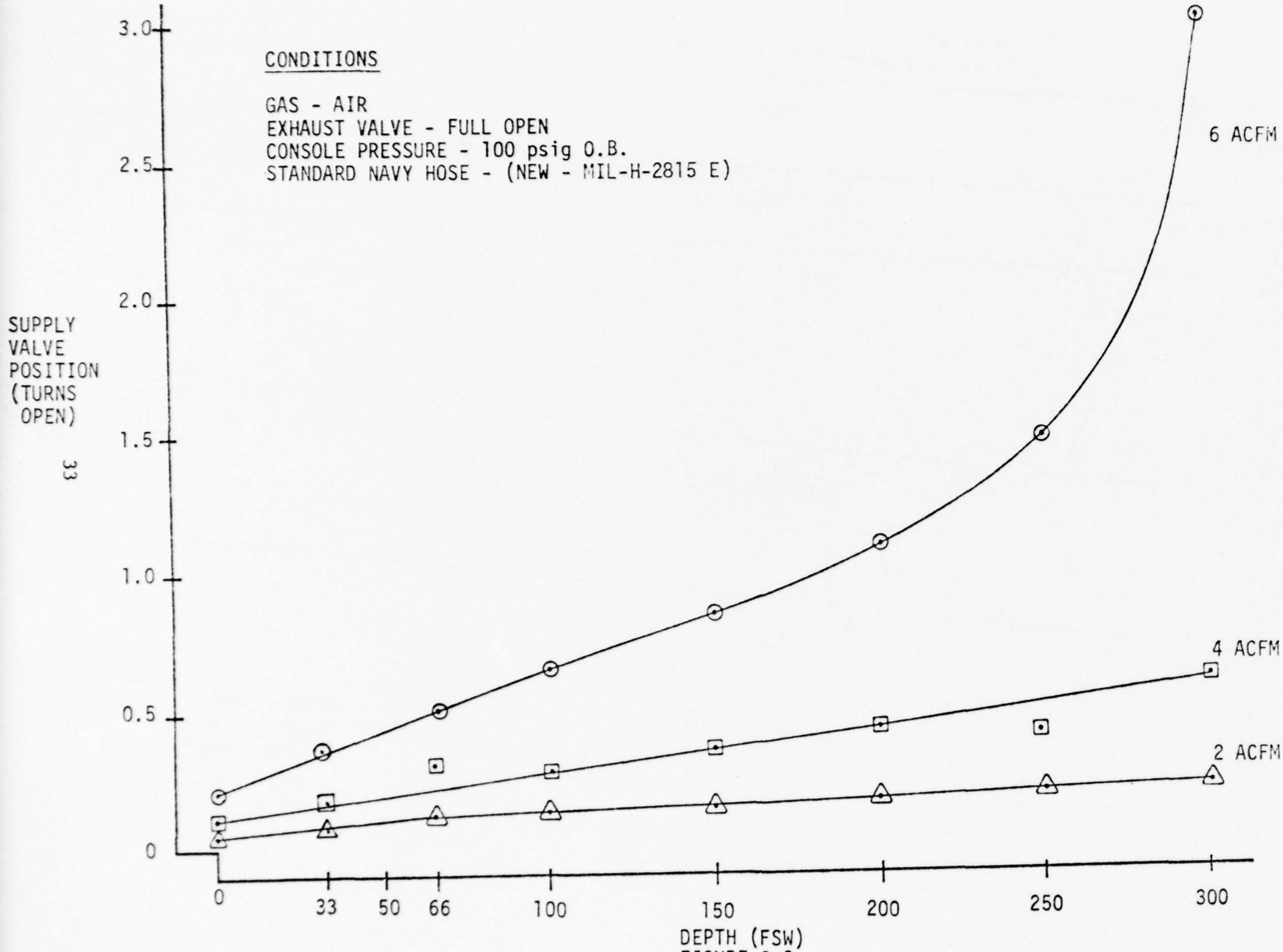


FIGURE 3-2

21 - 25 MAY 1976

MK 12 SSDS - TECHEVAL
HELMET Δ P vs. DEPTH
6 ACFM

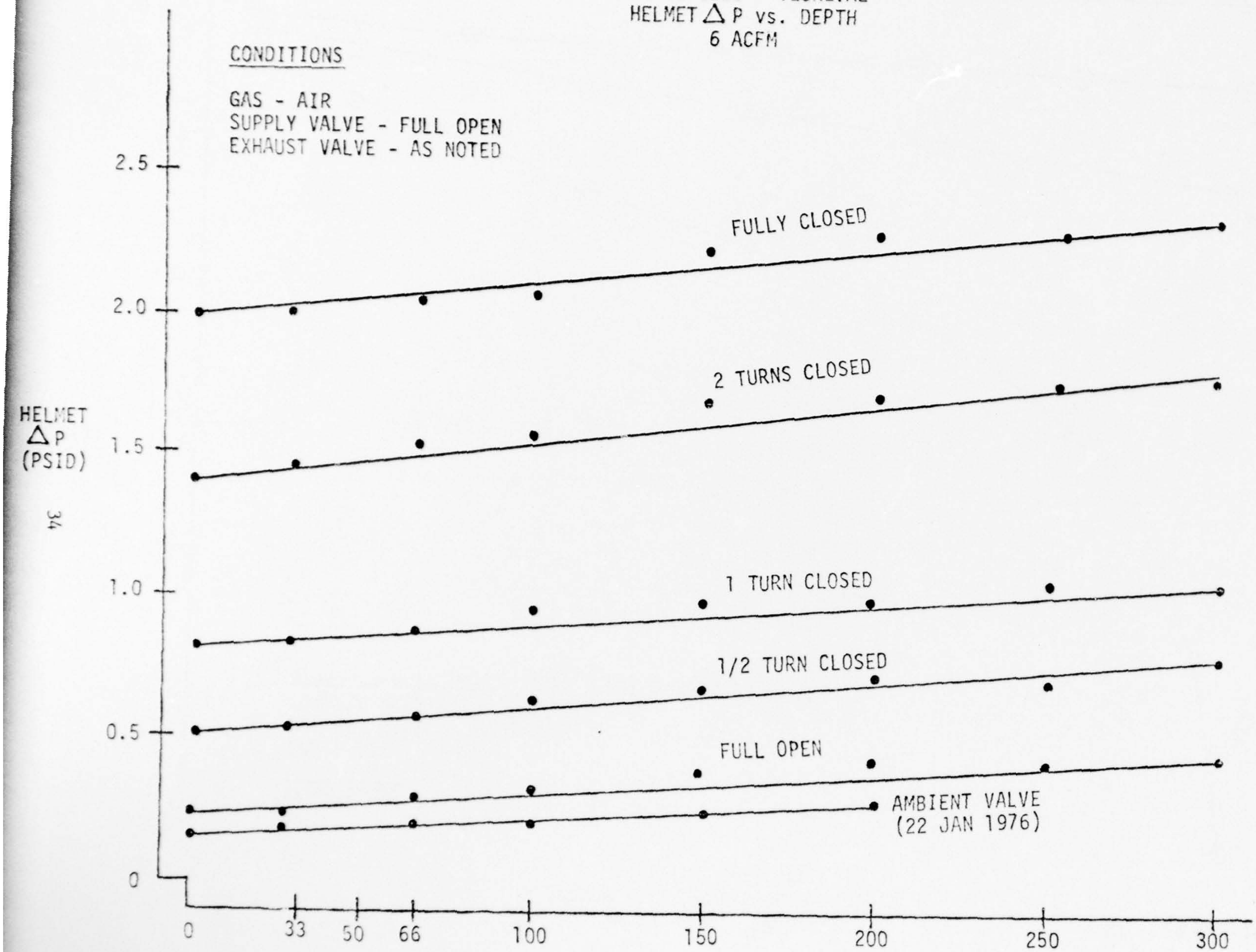


FIGURE 3-3

21 - 25 MAY 1976

MK 12 SSDS - TECHEVAL

HELMET Δ P vs. DEPTH
4 ACFM

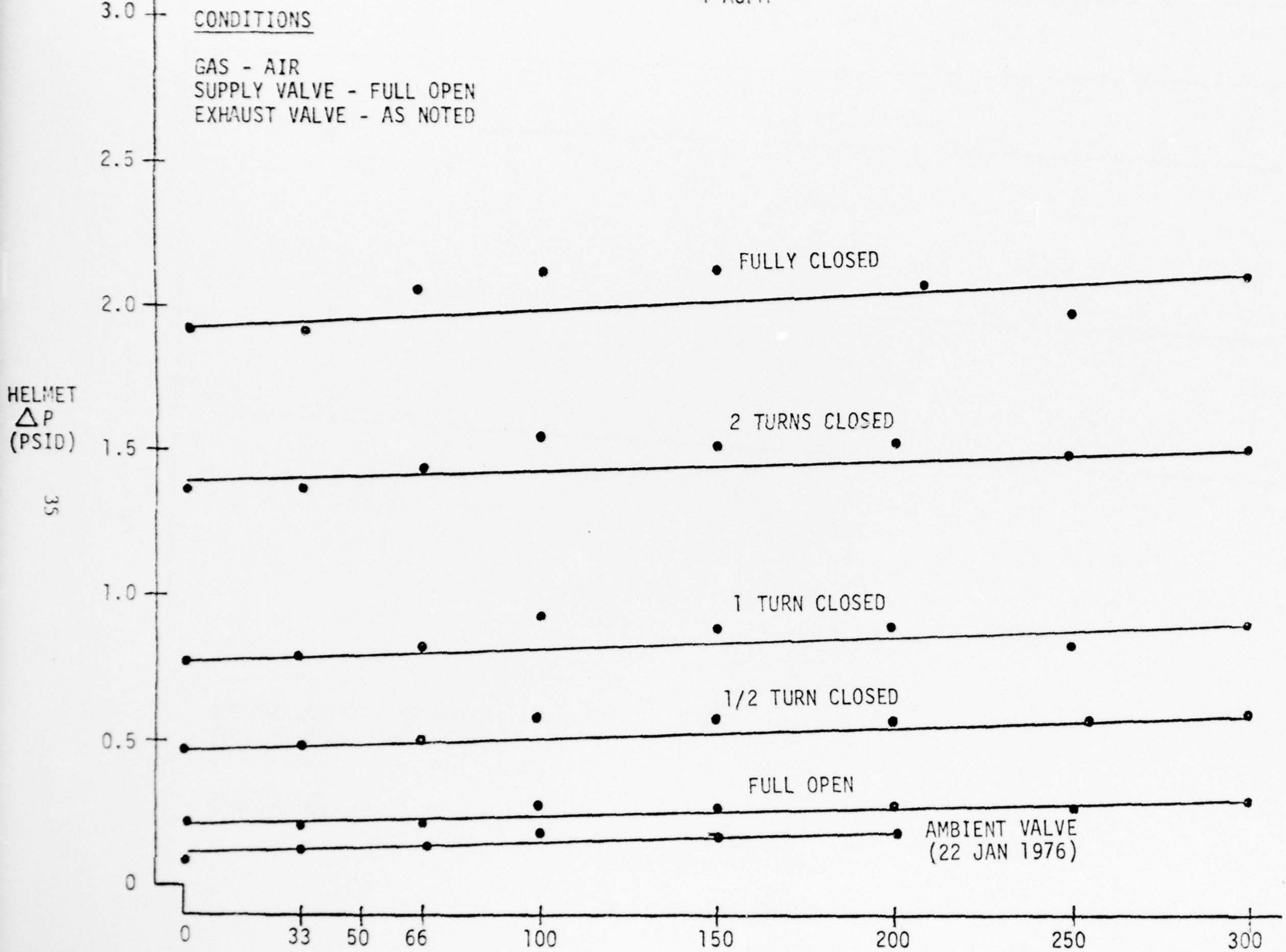


FIGURE 3-4

21 - 25 MAY 1976

MK 12 SSDS - TECHEVAL

HELMET Δ P vs. DEPTH
2 ACFM

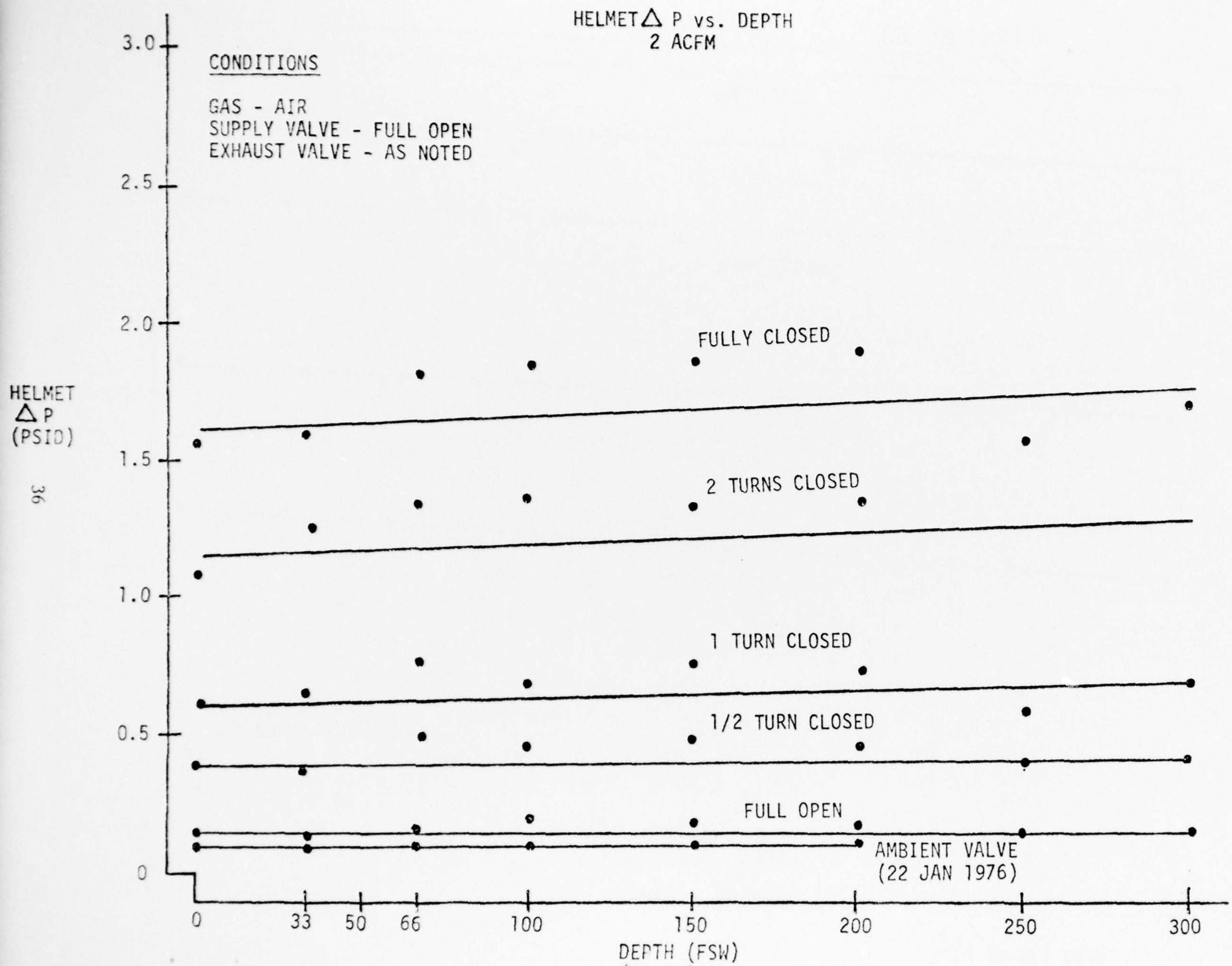


FIGURE 3-5

2 June 1976

MK 12 SSDS
CO_2 VENTILATION
CO_2 LEVEL Vs. DEPTH

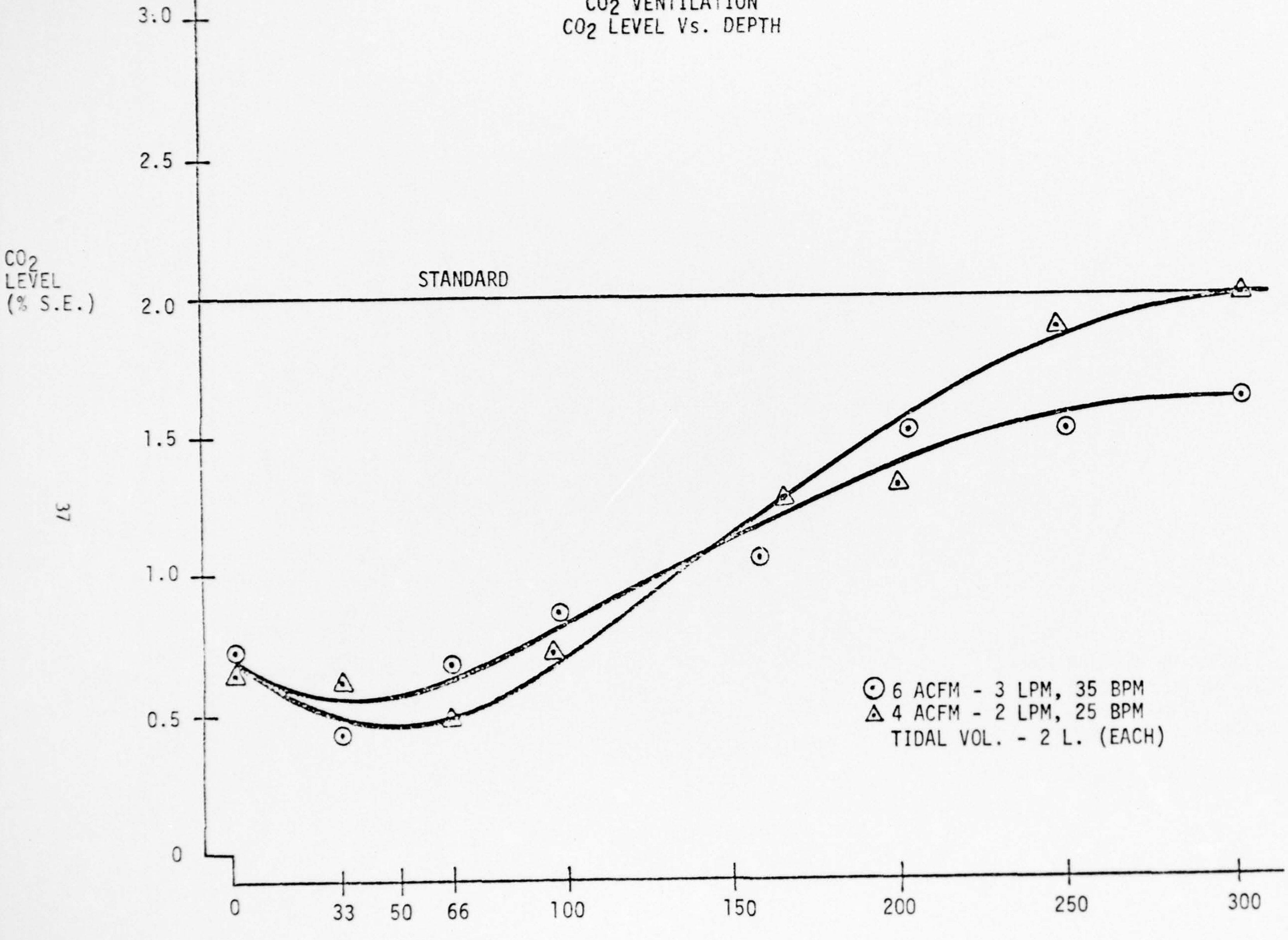


FIGURE 3-6

MK 12 SSDS - TECHEVAL
NOISE LEVEL Vs. FREQUENCY

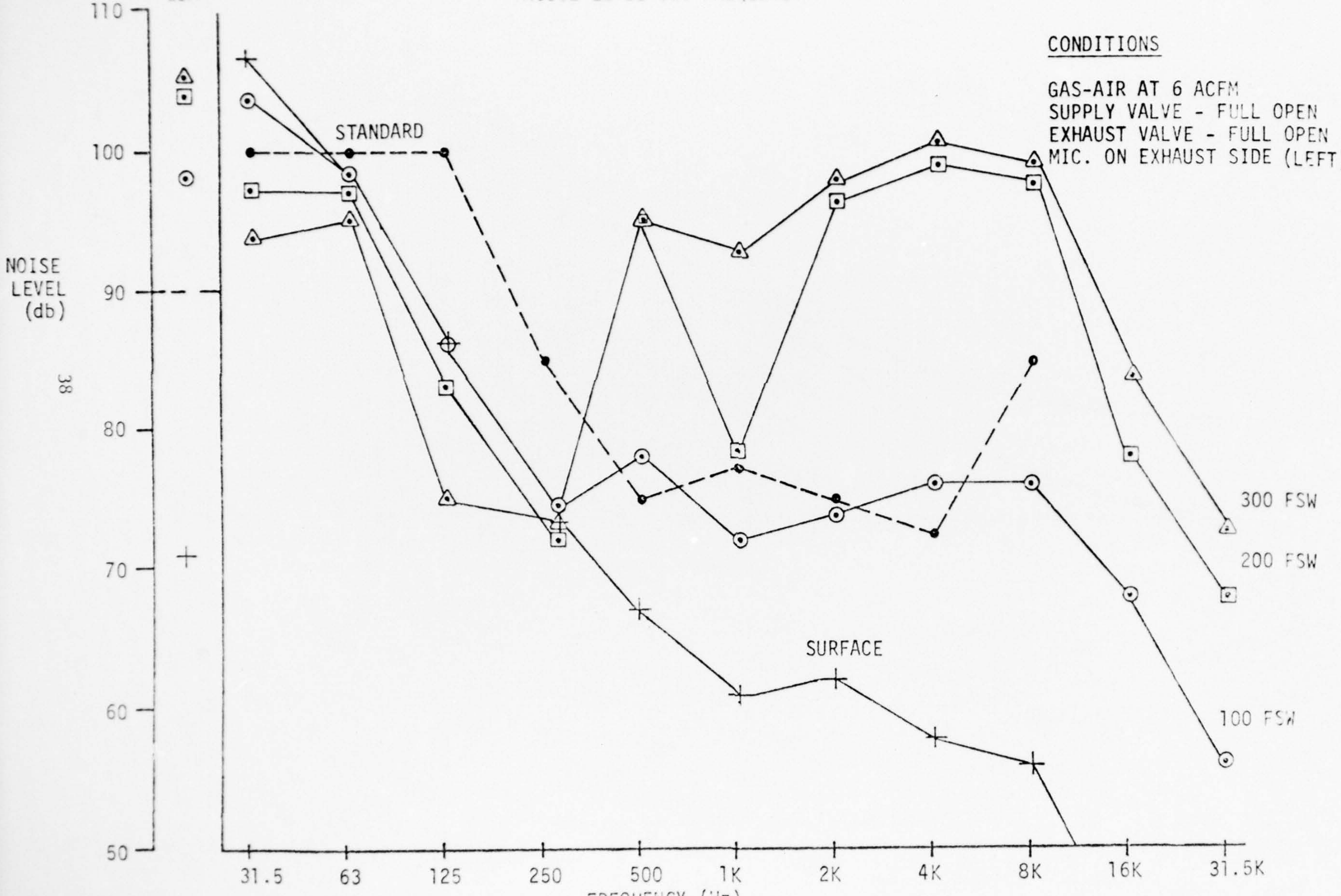
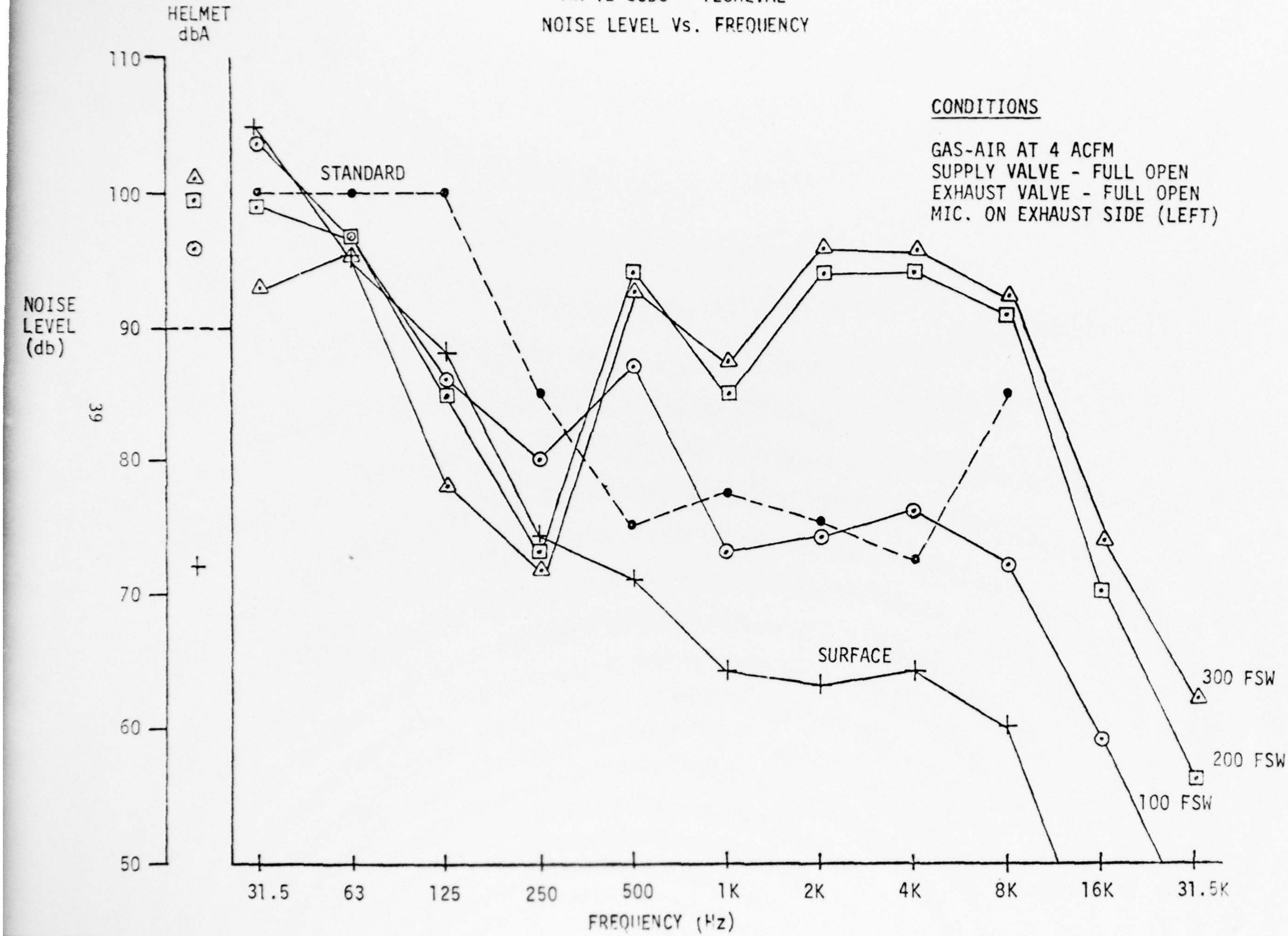


FIGURE [illegible]7

MK 12 SSDS - TECHEVAL
NOISE LEVEL Vs. FREQUENCY



MK 12 SSDS - TECHEVAL
NOISE LEVEL Vs. FREQUENCY

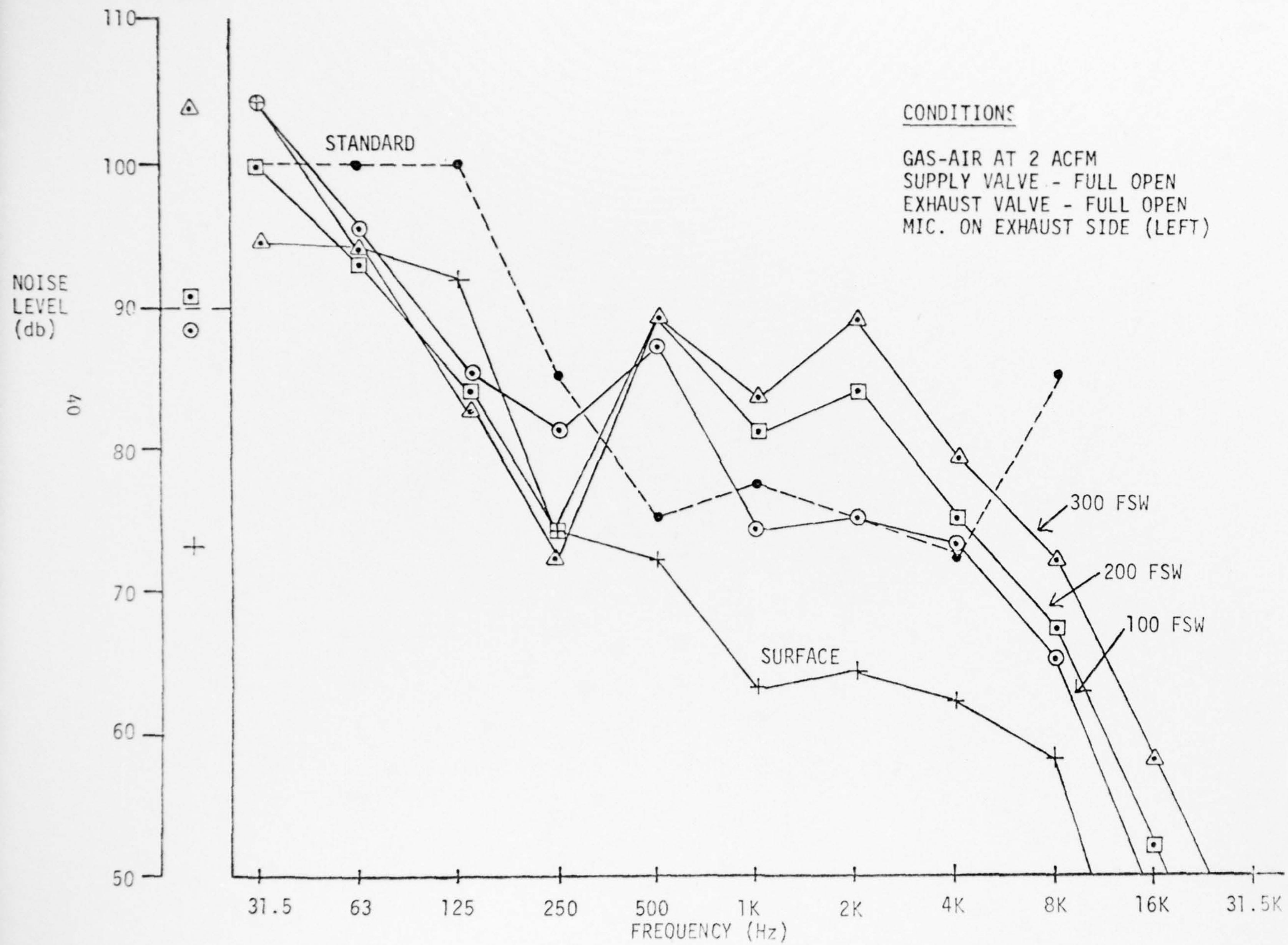


FIGURE 3-9

3.4.2 Noise Level. In a manikin test on the surface the system is extremely quiet, 71 dbA against a standard of 90. At 100 FSW the measured noise level is marginal when compared to OSHA standard. It should be noted that (a) when considering the normal maximum air dive time limit of 5 hours, the MK 12 system is almost within noise limits, since the 90 dbA level is based upon an 8 hour period; (b) a single reduction of 6 dbA will cut noise sound pressure level in half; (c) very little is known about noise level effects on the ears at depth; and (d) more research is required on this subject before definite judgements on noise level in a diving system may be made.

3.5 Summary. The MK 12 SSDS air mode meets all required physical standards. A new helmet liner and a new gas diffuser have reduced the noise level on the surface by 9 dbA in a simple laboratory test. Continued testing at depths deeper than 100 FSW will determine if similar benefit will be realized at the greater depths.

Section 4

TOOL DEMONSTRATION TESTS

4.1 General. This manned test series was developed to demonstrate that the MK 12 SSDS air mode was compatible with standard Navy underwater tools, including welding and cutting equipment.

4.1.1 Location. This dive series was conducted at the NCSL East Pier diving station during the period 16-20 February 1976.

4.1.2 Personnel. NEDU personnel, including MK 12 Project personnel, performed the required dives.

4.2 Scope of Testing.

4.2.1 Conduct. This test was conducted in accordance with Table A-4 of Annex A and Annex D of the TECHEVAL Test Plan, Mark 12 Surface Supported Diving System, T/S 283.

4.2.2 Specific Tests. Dives were planned to demonstrate the capability of the MK 12 system to use the following underwater tools:

- Impact wrench (2 tasks)
- Grinder
- Hydraulic Cutting Tool (ENERPAC)
- Welding equipment
- Cutting torch

4.3 Results.

4.3.1 Tasks. All tasks were performed in a satisfactory manner for a total of 59 dives with no aborts. Most divers commented that additional weight was required when using the underwater tools, particularly the grinder, to remain planted on the bottom. Consequently four additional weight pockets for a total of 20 extra pounds have been added to the dry suit. This test series was very popular with the divers, and several indicated in their comments that the dive series was too brief. Total underwater welding time was 2 hours and 51 minutes with no evidence of electrolytic deterioration on metal parts of the system.

4.4 Summary. A diver using the MK 12 SSDS is able to operate standard Navy underwater tools and equipment.

Section 5

MAXIMUM LIMITS TESTS

5.1 General. This manned test series was designed to demonstrate that the MK 12 SSDS air mode is able to dive to 250 FSW, the maximum required air diving limit.

5.1.1 Location. This dive series was performed in the NEDU Ocean Simulation Facility (OSF), Panama City, Florida and conducted during the period 23-27 February and 10-11 May 1976. The May series was required because the OSF was not available during part of the earlier period for either mechanical or operational reasons.

5.1.2 Personnel. NEDU personnel, including MK 12 Project personnel, performed the required tests.

5.2 Scope of Testing.

5.2.1 Conduct. This test series was conducted in accordance with Table A-5 of Annex A of the TECHEVAL Test Plan, MARK 12 Surface Supported Diving System, T/S 283.

5.2.2 Specific Tests. This test series was planned as a group of successively deeper dives from 50 FSW to 250 FSW to allow the diving team to become acclimated to deeper diving.

5.3 Results. A total of 26 dives was conducted during this test series with no aborts to a depth of 250 FSW. In February, dives to 200 FSW were completed. In May, dives to 250 FSW were accomplished. Dives to 300 FSW, the extreme air mode depth in the U.S. Navy Diving Manual and the maximum demonstration air dive at diving training facilities, will be performed at a later date.

5.4 Summary. The MK 12 SSDS air mode is capable of diving to the required depth of 250 FSW.

Section 6

RELIABILITY TESTS

6.1 General. This manned test series was designed to demonstrate that the MK 12 SSDS air mode could operate in a reliable manner while performing a large number of dives in a continuous and sustained diving evolution.

6.1.1 Location. This dive series was conducted from the NCSL Stage II diving platform in the Gulf of Mexico off Panama City Beach, Florida, during the period 17-26 March 1976.

6.1.2 Personnel. Individuals from various Fleet Diving units from around the U.S. and NEDU MK 12 Project personnel performed the required dives.

6.2 Scope of Testing.

6.2.1 Conduct. This test series was conducted in accordance with Table A-6 of Annex A of the TECHEVAL Test Plan, Mark 12 Surface Supported Diving System, T/S 283.

6.2.2 Specific Tests. A total of 140 dives, 14 per day, was scheduled for this period. Dives were performed in sets of two divers, one in the bottom configuration with the adjustable exhaust valve in the helmet and the other in the swimming configuration with the ambient exhaust valve in the helmet. Simple tasks were accomplished by the divers after a series of open water familiarization dives. Tasks included: hogging line, pipe square, pipe flange, and an indoctrination on the latest version of the Pipe Puzzle (Tooker patch, J-bolt patch, and bolting on a cover).

6.3 Results.

6.3.1 Operations. A total of 191 dives was completed during this series with no aborts, 96 in the bottom configuration and 95 in the swimming configuration. The divers found the MK 12 system comfortable and mobile and were able to perform all tasks easily. Routine diving operations could have continued beyond the scheduled two week period without any special effort.

6.3.2 Maintenance. Pre-dive, post-dive, and turnaround checks as well as the preventive maintenance procedures proved effective. There was little down time for repairs and most material failures were discovered during routine checks. At the end of the diving period the diving equipment was in as good a material condition as at the beginning.

6.4 Summary. The MK 12 SSDS air mode has demonstrated an excellent capability for sustained diving operations with high reliability figures.

Section 7

OTHER TESTING

7.1 General. Temperature limitation and dive duration testing were conducted prior to the TECHEVAL period. The results are included in this report as pertinent to the establishment of actual system characteristics.

7.1.1 Location. These dive series were conducted in the NEDU OSF pool and the NCSL Hydrospace Laboratory in December 1975 and January 1976.

7.1.2 Personnel. NEDU MK 12 Project personnel performed the manned portion of the dives.

7.2 Scope of Testing

7.2.1 Conduct. These tests were conducted as both manned and unmanned tests in accordance with the following NEDU MK 12 SSDS protocols: Duration Tests and Temperature Limitation Tests.

7.2.2 Specific Tests

7.2.2.1 Duration. Dives were planned to demonstrate that the MK 12 SSDS was capable of properly operating for a period of five hours. Three unmanned dives preceeded the manned dive.

7.2.2.2 Temperature. Dives were planned to demonstrate that the MK 12 SSDS would operate properly at extreme temperature ranges. Unmanned testing limits were at 120°F and 29°F. Utilizing a different test set up, the manned diving was limited to 93°F by the NEDU Medical Officer and to 33°F by the available water cooling system. The upper temperature limit (93°F) was selected to ensure that the diver would not be subjected to severe heat stress. All dives were for a minimum of one hour in approximately 15 feet of water.

7.3 Results.

7.3.1 Duration. The MK 12 SSDS performed well through the entire test series. At the end of the manned dive the diver was comfortable, and the system was ready to go back in the water for the next required dive. See MK 12 SSDS Report 7-75, Duration Test Results.

7.3.2 Temperature. The high temperature dives were performed satisfactorily and with little discomfort. The unmanned cold water dive went to 27.8°F and was performed satisfactorily with no icing in any part of the system. During the manned phase an equipment malfunction limited the temperature to 35°F, but the dive was performed in a satisfactory manner with minimum discomfort. See MK 12 SSDS Report 1-76, Temperature Limitation Test Results.

7.4 Summary. The MK 12 SSDS air mode is capable of operation in water with a temperature range of 29°F to 120°F, although manned diving is currently limited to an upper temperature of 93°F for medical reasons. Further, the system has operated for 5 hours, the maximum required time, without diver discomfort or equipment failure.

Section 8

SUMMARY

8.1 General. The TECHEVAL of the MK 12 SSDS was completed in a satisfactory manner. While requirements for several minor equipment modifications became apparent during the course of the test period, all parts of the diving system functioned as designed. In addition, diver acceptance was positive and enthusiastic. A summary of the test results is provided in Table 8-1.

8.2 Required Modifications. The system modifications which follow are the result of TECHEVAL experience.

8.2.1 Helmet Assembly.

Noise Level - An improved helmet liner and air supply diffuser are required to reduce the noise level.

Exhaust Valve - Redesign of the chin button is required to insure that the button does not pull off.

Metal Finish - The black chrome coating in some areas requires replacement by a more durable finish or a better coating process.

Air, Mixed Gas and Electrical Adapters - All four of these adapters require redesign to eliminate leaking.

8.2.2 Dress Assembly.

Dry Suit Sizing - All sizes of dry suit need to be scaled up to conform to the sizing of the Navy diver population.

Lower Breech Ring - The lower (suit) breech ring latch fitting requires redesign to ease tolerances so that slight misalignment can be accepted and to beef up the lug to make it more durable.

Weights - The outer garment requires modification to permit use of more weight.

Jocking Harness - This item requires a positive lock to prevent inadvertent release.

Boot Sizing - Boots are required in larger, wider sizes.

8.2.3 Support Equipment.

Communication/Strength Cable - A cable protective cover which is more resistant to abrasion is required.

EVALUATION CRITERIA	REQUIRED	1976 TECHEVAL RESULTS (AIR)
RELIABILITY (1) Life Support (2) Mission	 0.975 at 95% conf. 0.900 at 90% conf.	 0.986 at 95% confidence 0.992 at 90% confidence
Operational Availability	0.75 at 90% conf.	0.903 at 90% confidence
Reaction Time	30 minutes	19.9 minutes (air)
Turnaround Time	20 minutes	7.4 minutes (air)
Mean Time to Repair	4 hours	0.22 hours
Interface	Must interface with Navy Diving Ships	No difficulties encountered
Safety	Equal to or better than MK V	Better than MK V
CO_2 Level	<2% Surface equivalent desired <3% S.E. absolute max.	<2.0% S.E. 6 ACFM - 1.6% S.E. 4 ACFM - 2.0% S.E.
Flow	$\geq$4.5 ACFM	>6 ACFM
Venturi Efficiency	5 to 10	N.A. (air)
Sound Level	<90dbA	71dbA to 105dbA
Comfort	Equal to or better than MK V	Better than MK V
Visibility	Equal to or better than MK V	Better than SCUBA
Mobility	Equal to or better than MK V	Better than MK V
Durability	Equal to or better than MK V	Better than MK V
Buoyancy Control	Equal to or better than MK V	Better than MK V

TABLE 8-1 MK 12 TECHNICAL EVALUATION SUMMARY

__Welding Shield__ - An improved welding lens for underwater use is required.

8.3 __Conclusion.__ The MK 12 SSDS is ready for OPEVAL now and will be improved with the addition of the modifications noted above.